CLAIMS

1. An image recognition apparatus which compares an object image containing a plurality of objects with a model image containing a model to be detected and extracts the model from the object image, the apparatus comprising:

feature point extracting means for extracting a feature point from each of the object image and the model image;

feature quantity retention means for extracting and retaining, as a feature quantity, a density gradient direction histogram at least acquired from density gradient information in a neighboring region at the feature point in each of the object image and the model image;

feature quantity comparison means for comparing each feature point of the object image with each feature point of the model image and generating a candidate-associated feature point pair having similar feature quantities; and

model attitude estimation means for detecting the presence or absence of the model on the object image using the candidate-associated feature point pair and estimating a position and an attitude of the model, if any,

wherein the feature quantity comparison means itinerantly shifts one of the density gradient direction histograms of feature points to be compared in density gradient direction to find distances between the density gradient direction histograms and generates the candidate-associated feature point pair by assuming a shortest

distance to be a distance between the density gradient direction histograms.

2. The image recognition apparatus according to claim 1,

wherein the feature quantity retention means extracts and retains, as the feature quantity, an average density gradient vector for each of plurality of partial regions into which the neighboring region is further divided, and

the feature quantity comparison means generates the candidate-associated feature point pair based on a distance between density gradient direction histograms for the feature points to be compared and on similarity between feature vectors which are collected in the neighboring region as average density gradient vectors in each of the partial regions.

3. The image recognition apparatus according to claim 2, wherein the feature quantity comparison means generates a provisional candidate-associated feature point pair based on a distance between the density gradient direction histograms for the feature points to be compared and, based on the similarity between feature vectors, selects the candidate-associated feature point pair from the provisional candidate-associated feature point pair.

4. The image recognition apparatus according to claim 3, wherein the feature quantity comparison means uses a rotation angle equivalent to a shift amount giving the shortest distance to correct a density gradient direction of a density gradient vector in the neighboring region and selects the candidate-associated feature point pair from the provisional candidate-associated feature point pair based on similarity between the

feature vectors in a corrected neighboring region.

5. The image recognition apparatus according to claim 1, wherein the model attitude estimation means repeatedly projects an affine transformation parameter determined from three randomly selected candidate-associated feature point pairs onto a parameter space and finds an affine transformation parameter to determine a position and an attitude of the model based on an affine transformation parameter belonging to a cluster having the largest number of members out of clusters formed on a parameter space.

6. The image recognition apparatus according to claim 5, wherein the model attitude estimation means assumes a centroid for the cluster having the largest number of members to be an affine transformation parameter to determine a position and an attitude of the model.

7. The image recognition apparatus according to claim 5, wherein the model attitude estimation means assumes a candidate-associated feature point pair giving the affine transformation parameter belonging to a cluster having the largest number of members to be a true candidate-associated feature point pair and uses the true candidate-associated feature point pair for least squares estimation to find an affine transformation parameter for determining a position and an attitude of the model.

8. The image recognition apparatus according to claim 1, further comprising:

candidate-associated feature point pair selection means for creating a rotation angle histogram concerning a rotation angle equivalent to a shift amount giving the

shortest distance and selects a candidate-associated feature point pair giving a rotation angle for a peak in the rotation angle histogram from the candidate-associated feature point pair generated by the feature quantity comparison means,

wherein the model attitude estimation means detects the presence or absence of the model on the object image using a candidate-associated feature point pair selected by the candidate-associated feature point pair selection means and estimates a position and an attitude of the model, if any.

9. The image recognition apparatus according to claim 1, further comprising:

candidate-associated feature point pair selection means for performing generalized Hough transform for a candidate-associated feature point pair generated by the feature quantity comparison means, assuming a rotation angle, enlargement and reduction ratios, and horizontal and vertical linear displacements to be a parameter space, and selecting a candidate-associated feature point pair having voted for the most voted parameter from candidate-associated feature point pairs generated by the feature quantity comparison means,

wherein the model attitude estimation means detects the presence or absence of the model on the object image using a candidate-associated feature point pair selected by the candidate-associated feature point pair selection means and estimates a position and an attitude of the model, if any.

10. The image recognition apparatus according to claim 1, wherein the feature point extraction means extracts a local maximum point or a local minimum point in

second-order differential filter output images with respective resolutions as the feature point, i.e., a point free from positional changes due to resolution changes within a specified range in a multi-resolution pyramid structure acquired by repeatedly applying smoothing filtering and reduction resampling to the object image or the model image.

11. An image recognition apparatus which compares an object image containing a plurality of objects with a model image containing a model to be detected and extracts the model from the object image, the apparatus comprising:

feature point extracting means for extracting a feature point from each of the object image and the model image;

feature quantity retention means for extracting and retaining a feature quantity in a neighboring region at the feature point in each of the object image and the model image;

feature quantity comparison means for comparing each feature point of the object image with each feature point of the model image and generating a candidate-associated feature point pair having similar feature quantities; and

model attitude estimation means for detecting the presence or absence of the model on the object image using the candidate-associated feature point pair and estimating a position and an attitude of the model, if any,

wherein the model attitude estimation means repeatedly projects an affine transformation parameter determined from three randomly selected

candidate-associated feature point pairs onto a parameter space and finds an affine transformation parameter to determine a position and an attitude of the model based on an affine transformation parameter belonging to a cluster having the largest number of members out of clusters formed on a parameter space.

12. The image recognition apparatus according to claim 11, wherein the model attitude estimation means assumes a centroid for the cluster having the largest number of members to be an affine transformation parameter to determine a position and an attitude of the model.

13. The image recognition apparatus according to claim 11, wherein the model attitude estimation means assumes a candidate-associated feature point pair giving the affine transformation parameter belonging to a cluster having the largest number of members to be a true candidate-associated feature point pair and uses the true candidate-associated feature point pair for least squares estimation to find an affine transformation parameter for determining a position and an attitude of the model.

14. The image recognition apparatus according to claim 11, further comprising:

candidate-associated feature point pair selection means for performing generalized Hough transform for a candidate-associated feature point pair generated by the feature quantity comparison means, assuming a rotation angle, enlargement and reduction ratios, and horizontal and vertical linear displacements to be a parameter space, and selecting a candidate-associated feature point pair having voted for the most voted parameter from candidate-associated feature point pairs generated by the

feature quantity comparison means,

wherein the model attitude estimation means detects the presence or absence of the model on the object image using a candidate-associated feature point pair selected by the candidate-associated feature point pair selection means and estimates a position and an attitude of the model, if any.

15. The image recognition apparatus according to claim 1, wherein the feature point extraction means extracts a local maximum point or a local minimum point in second-order differential filter output images with respective resolutions as the feature point, i.e., a point free from positional changes due to resolution changes within a specified range in a multi-resolution pyramid structure acquired by repeatedly applying smoothing filtering and reduction resampling to the object image or the model image.

16. An image recognition method which compares an object image containing a plurality of objects with a model image containing a model to be detected and extracts the model from the object image, the method comprising:

a feature point extracting step of extracting a feature point from each of the object image and the model image;

a feature quantity retention step of extracting and retaining, as a feature quantity, a density gradient direction histogram at least acquired from density gradient information in a neighboring region at the feature point in each of the object image and the model image;

a feature quantity comparison step of comparing each feature point of the object image with each feature point of the model image and generating a candidate-associated feature point pair having similar feature quantities; and

a model attitude estimation step of detecting the presence or absence of the model on the object image using the candidate-associated feature point pair and estimating a position and an attitude of the model, if any,

wherein the feature quantity comparison step itinerantly shifts one of the density gradient direction histograms of feature points to be compared in density gradient direction to find distances between the density gradient direction histograms and generates the candidate-associated feature point pair by assuming a shortest distance to be a distance between the density gradient direction histograms.

17. An image recognition method which compares an object image containing a plurality of objects with a model image containing a model to be detected and extracts the model from the object image, the method comprising:

a feature point extracting step of extracting a feature point from each of the object image and the model image;

a feature quantity retention step of extracting and retaining a feature quantity in a neighboring region at the feature point in each of the object image and the model image;

a feature quantity comparison step of comparing each feature point of the object image with each feature point of the model image and generating a

candidate-associated feature point pair having similar feature quantities; and

a model attitude estimation step of detecting the presence or absence of the model on the object image using the candidate-associated feature point pair and estimating a position and an attitude of the model, if any,

wherein the model attitude estimation step repeatedly projects an affine transformation parameter determined from three randomly selected candidate-associated feature point pairs onto a parameter space and finds an affine transformation parameter to determine a position and an attitude of the model based on an affine transformation parameter belonging to a cluster having the largest number of members out of clusters formed on a parameter space.

18. An autonomous robot apparatus capable of comparing an input image with a model image containing a model to be detected and extracting the model from the input image, the apparatus comprising:

image input means for imaging an outside environment to generate the input image;

feature point extracting means for extracting a feature point from each of the input image and the model image;

feature quantity retention means for extracting and retaining, as a feature quantity, a density gradient direction histogram at least acquired from density gradient information in a neighboring region at the feature point in each of the input image and the model image;

feature quantity comparison means for comparing each feature point of the input image with each feature point of the model image and generating a candidate-associated feature point pair having similar feature quantities; and

model attitude estimation means for detecting the presence or absence of the model on the input image using the candidate-associated feature point pair and estimating a position and an attitude of the model, if any,

wherein the feature quantity comparison means itinerantly shifts one of the density gradient direction histograms of feature points to be compared in density gradient direction to find distances between the density gradient direction histograms and generates the candidate-associated feature point pair by assuming a shortest distance to be a distance between the density gradient direction histograms.

19. An autonomous robot apparatus capable of comparing an input image with a model image containing a model to be detected and extracting the model from the input image, the apparatus comprising:

image input means for imaging an outside environment to generate the input image;

feature point extracting means for extracting a feature point from each of the input image and the model image;

feature quantity retention means for extracting and retaining a feature quantity in a neighboring region at the feature point in each of the input image and the model image;

feature quantity comparison means for comparing each feature point of the input image with each feature point of the model image and generating a candidate-associated feature point pair having similar feature quantities; and

model attitude estimation means for detecting the presence or absence of the model on the input image using the candidate-associated feature point pair and estimating a position and an attitude of the model, if any,

wherein the model attitude estimation means repeatedly projects an affine transformation parameter determined from three randomly selected candidate-associated feature point pairs onto a parameter space and finds an affine transformation parameter to determine a position and an attitude of the model based on an affine transformation parameter belonging to a cluster having the largest number of members out of clusters formed on a parameter space.